# Exhibit A

Overview of Network Load Balancing

Applies To: Windows Server 2008 R2

The Network Load Balancing (NLB) feature in Windows Server 2008 R2 enhances the availability and scalability of Internet server applications such as those used on Web, FTP, firewall, proxy, virtual private network (VPN), and other mission-critical servers. A single computer running Windows Server 2008 R2 provides a limited level of server reliability and scalable performance. However, by combining the resources of two or more computers running one of the products in Windows Server 2008 R2 into a single virtual cluster, NLB can deliver the reliability and performance that Web servers and other mission-critical servers need.
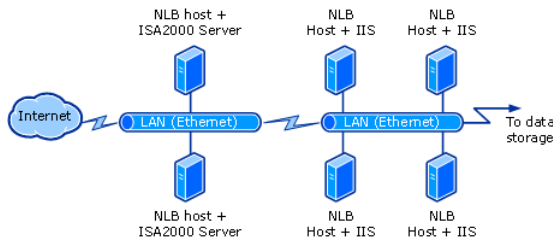
The diagram above depicts two connected Network Load Balancing clusters. The first cluster consists of two hosts and the second cluster consists of four hosts. This is one example of how you can use NLB.

Each host runs a separate copy of the desired server applications (such as applications for Web, FTP, and Telnet servers). NLB distributes incoming client requests across the hosts in the cluster. The load weight to be handled by each host can be configured as necessary. You can also add hosts dynamically to the cluster to handle increased load. In addition, NLB can direct all traffic to a designated single host, which is called the default host.

NLB allows all of the computers in the cluster to be addressed by the same set of cluster IP addresses, and it maintains a set of unique, dedicated IP addresses for each host. For load-balanced applications, when a host fails or goes offline, the load is automatically redistributed among the computers that are still operating. When a computer fails or goes offline unexpectedly, active connections to the failed or offline server are lost. However, if you bring a host down intentionally, you can use the **drainstop** command to service all active connections prior to bringing the computer offline. In any case, when it is ready, the offline computer can transparently rejoin the cluster and regain its share of the workload, which allows the other computers in the cluster to handle less traffic.

The hosts in an NLB cluster exchange heartbeat messages to maintain consistent data about the cluster's membership. By default, when a host fails to send heartbeat messages within five seconds, it has failed. When a host has failed, the remaining hosts in the cluster converge and do the following:

- Establish which hosts are still active members of the cluster.

- Elect the host with the highest priority as the new default host.

- Ensure that all new client requests are handled by the surviving hosts.

During a convergence, the surviving hosts look for consistent heartbeats. If the host that failed to send heartbeats begins to provides heartbeats consistently, it rejoins the cluster in the course of the convergence. When a new host attempts to join the cluster, it sends heartbeat messages that also trigger a convergence. After all cluster hosts agree on the current cluster membership, the client load is redistributed to the remaining hosts, and the convergence completes.

Convergence generally takes only a few seconds, so interruption in client service by the cluster is minimal. During convergence, hosts that are still active continue handling client requests without affecting existing connections. Convergence ends when all hosts report a consistent view of the cluster membership and distribution map for several heartbeat periods.

What is new in NLB?

NLB includes the following improvements for Windows Server 2008 R2:

- **Extended affinity**. The Extended option preserves client affinity when the configuration of an NLB cluster is changed. This option also allows clients to keep affinity to a cluster host even if there are no active, existing connections from the client to the host.

- **Windows PowerShell for NLB clusters**. Windows PowerShell is a new command-line shell and scripting language. Windows PowerShell accelerates automation of system administration tasks. You can use Windows PowerShell to manage NLB clusters. For more information about using Windows PowerShell for NLB clusters, see http://go.microsoft.com/fwlink/?LinkId=140180.

- **Support for rolling upgrades**. NLB supports rolling upgrades from Windows Server 2003 to Windows Server 2008 R2 and from Windows Server 2008 to Windows Server 2008 R2. For deployment information for NLB, including information on rolling upgrades, see http://go.microsoft.com/fwlink/?LinkId=87253.

NLB configuration

NLB runs as a Windows networking driver. Its operations are transparent to the TCP/IP networking stack.
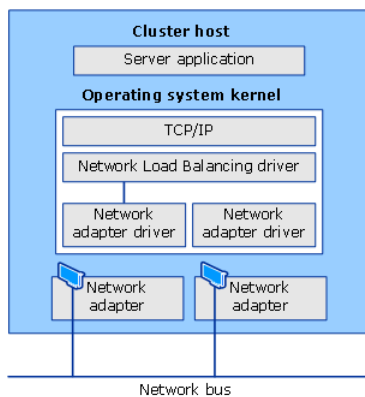
The diagram above shows the relationship between NLB and other software components in a typical configuration of a NLB host.

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Features in Network Load Balancing

NLB includes the following features:

Scalability

Scalability is the measure of how well a computer, service, or application can grow to meet increasing performance demands. For NLB clusters, scalability is the ability to incrementally add one or more systems to an existing cluster when the overall load of the cluster exceeds its capabilities. To support scalability, NLB can do the following:

- Balance load requests across the NLB cluster for individual TCP/IP services.

- Support up to 32 computers in a single cluster.

- Balance multiple server load requests (from either the same client or from several clients) across multiple hosts in the cluster.

- Support the ability to add hosts to the NLB cluster as the load goes up, without bringing the cluster down.

- Support the ability to remove hosts from the cluster when the load goes down.

- Enable high performance and low overhead through fully pipelined implementation. Pipelining allows requests to be sent to the NLB cluster without waiting for response to the previously sent one.

High-availability

A highly available system reliably provides an acceptable level of service with minimal downtime. To provide high availability, NLB includes built-in features that can automatically:

- Detect and recover from a cluster host that fails or goes offline.

- Balance the network load when hosts are added or removed.

- Recover and redistribute the workload within ten seconds.

Manageability

NLB provides the following manageability features:

- You can manage and configure multiple NLB clusters and the cluster hosts from a single computer by using NLB Manager.

- You can specify the load balancing behavior for a single IP port or group of ports by using port management rules.

- You can define different port rules for each Web site. If you use the same set of load-balanced servers for multiple applications or Web sites, port rules are based on the destination virtual IP address (using virtual clusters).

- You can direct all client requests to a single host by using optional, single-host rules. NLB routes client requests to a particular host that is running specific applications.

- You can block undesired network access to certain IP ports.

- You can enable Internet Group Management Protocol (IGMP) support on the cluster hosts to control switch flooding (when operating in multicast mode).

- You can remotely start, stop, and control NLB actions from any networked computer that is running Windows by using shell commands or scripts.

- You can view the Windows event log to check NLB events. NLB logs all actions and cluster changes in the event log.

Ease-of-use

NLB provides many features that make it convenient to use:

- NLB is installed as a standard Windows networking driver component.

- NLB requires no hardware changes to enable and run.

- NLB Manager enables you to create new NLB clusters.

- NLB Manager enables you to configure and manage multiple clusters and all of the cluster's hosts from a single remote or local computer.

- NLB lets clients access the cluster by using a single, logical Internet name and virtual IP address—known as the cluster IP address (it retains individual names for each computer). NLB allows multiple virtual IP addresses for multihomed servers.

> 📒 **Note**
>
> In the case of virtual clusters, the servers do not need to be multihomed to have multiple virtual IP addresses.

- NLB can be bound to multiple network adapters, which allows you to configure multiple independent clusters on each host. Support for multiple network adapters differs from virtual clusters in that virtual clusters allow you to configure multiple clusters on a single network adapter.

- You do not have to modify server applications to run in an NLB cluster.

- If a cluster host fails and then is subsequently brought back online, NLB can be configured to automatically add that host to the cluster. The added host will then be able to start handling new server requests from clients.

- You can take computers offline for preventive maintenance without disturbing cluster operations on the other hosts.

Additional references

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Installing Network Load Balancing

Checklist: Getting Started with Network Load Balancing

Creating Network Load Balancing Clusters

Managing Network Load Balancing Clusters

Setting Network Load Balancing Parameters

Controlling Hosts on Network Load Balancing Clusters

Troubleshooting Network Load Balancing Clusters

User Interface: Network Load Balancing Manager

Community Additions

Windows PowerShell for NLB clusters

Windows PowerShell for NLB clusters (http://go.microsoft.com/fwlink/?LinkId=140180) link on this page is broken and incorrectly poits to **Windows Server Future Resources** (placeholder page). The correct link is **Network Load Balancing cmdlets in Windows PowerShell** (http://technet.microsoft.com/library/ee817138).

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